

EMC Design and Test Solutions

Introduction

Ensuring electromagnetic compatibility (EMC) is one of the most critical challenges for any electronic device developer. Such interference can cause devices such as laptops, Bluetooth players, smart watches, pacemakers, or hearing aids, to operate incorrectly or not meet country legal requirements. Depending on the severity of the interference and the type of affected device, the consequences can range from inconvenient to life-threatening for the user or fines or sanctions for the manufacturer.

EMC can be subdivided into Electromagnetic Interference (EMI) and Electromagnetic Susceptibility (EMS). EMI testing involves the measurements of noise generated from the Equipment Under Test (EUT) under normal operation. EMS testing measures the equipment's ability to withstand EMI signals from the surrounding environment.

This brochure will cover Keysight products for EMI and EMS testing.

- Keysight EMI receivers
- Keysight EMS testing products
- Keysight EMC simulation software
- Keysight pre-compliance and troubleshooting products
- EMI and EMS Compliance Test Solutions from Keysight + Partners

Keysight EMI Receiver Portfolio

Keysight offers a wide range of EMI test instruments for compliance testing, pre-compliance testing and troubleshooting.

- Compliance test labs and government regulatory testing agencies can rely on Keysight compliance test equipment to confirm products' performance and compliance with the respective regulatory body's EMC standards.
- Device manufacturers and designers can rely on Keysight pre-compliance test solutions to expose product weakness or failure early in the development cycle and troubleshooting tools to identify root cause and determine remedies.

EMI Troubleshooting

Basic Spectrum Analyzers (N9321C/22C/23C/24C BSA Series)

Cost effective tool for pre-compliance measurements with EMC bandwidths and quasi-peak detector.



Pre-compliance Receivers

FieldFox N99xxA/B

A lightweight, durable, cable and antenna analyzer, spectrum analyzer, network analyzer, power meter and more.



X-Series signal analyzers N90xxB

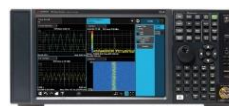
Perform pre-compliance measurements to commercial and military standards, with bandwidth and detectors meeting CISPR 16-1-1 and Mil-STD 461.



Compliance Receivers

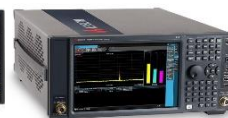
MXE N9038B

Perform standard-compliant EMI measurements
Reduce overall test time with time domain scan (TDS) enabled by FFT scans
Simplify measurement setup with large capacitive multi-touch screen



PXE N9048B

Perform real-time measurements without missing any transient noises or disturbances
Accelerate TDS with 350 MHz FFT bandwidth
Simultaneous display of Pk, QP and EMI Average results for enhanced test efficiency



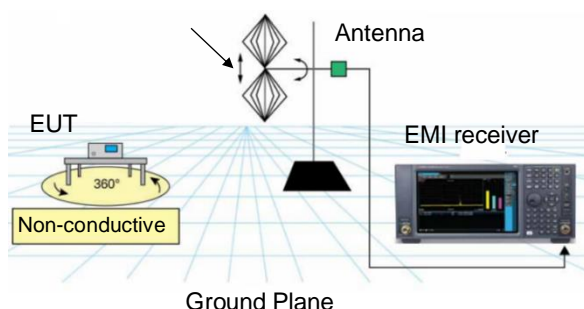
The EXA, MXE and PXE are based on the same X-Series Signal Analyzer platform allowing users to easily swap between receivers without spending long time to reprogram the automation software.

Key highlights	Pre-compliance Receivers		Compliance Receivers	
	FieldFox N99xxA/B	X-Series signal analyzers N90xxB	MXE N9038B	PXE N9048B
Freq range	30 kHz to 54 GHz	2 Hz to 110 GHz	3 Hz to 44 GHz	1 Hz to 44 GHz
Popular model and option for EMC	N9913B, option 233 spectrum analysis, option 361 EMC	N9010B EXA, E6141EM0E EMI measurement application	N9038B, N90EMTDSB Time domain scan	N9048B, N9048TDSB Time domain scan, N9048WT2B Accelerated time domain scan
Time-Domain Scan (TDS) bandwidth	Up to 12 MHz with N9913B	12 MHz	12 MHz	350 MHz
Compliance to	CISPR Detectors and BWs only	CISPR & MIL Detectors and BWs only	CISPR 16-1-1 & MIL-STD 461 full compliance	CISPR 16-1-1 and MIL-STD 461 full compliance
EMC detectors	Peak, Quasi-Peak, EMI Average	Peak, Quasi-Peak, EMI Average, RMS Average	Peak, Quasi-Peak, EMI Average, RMS Average	Peak, Quasi-Peak, EMI Average, RMS Average
Time Domain Scan (TDS)	Yes	Yes	Yes	Yes
Real time analysis	Yes	Yes	Yes	Yes, with EMI detectors, CISPR 16-1-1 compliant
Real time analysis bandwidth	Up to 100 MHz	Up to 2 GHz	Up to 160 MHz	Up to 350 MHz
Built-in limit lines	Yes	Yes	Yes	Yes
Report generation	No	Yes	Yes	Yes
More information	Solution brief – FieldFox All-in-One Pre-Compliance EMI Analyzer	Pre-compliance EMI measurements for X-Series Signal Analyzer - Brochure	Brochure – N9038B MXE EMI Receiver	Datasheet – Keysight N9048B PXE

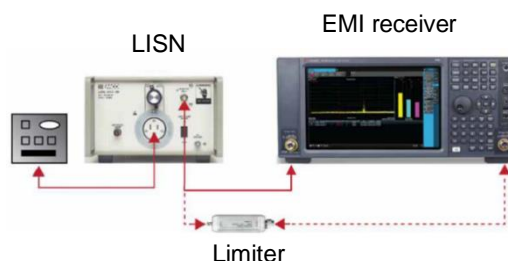
EMI Compliance Testing

EMI compliance testing involves the measurements of Radiated Emissions (RE) and Conducted Emission (CE) generated by the EUT under normal operation. EMI compliance testing assures that the EUT will not interfere the operations of surrounding electronic devices and involves the use of a standard-compliant EMI receiver for accurate measurement of emissions. Due to today's fast paced business environment and the quest for faster time to market, it is imperative to select the right equipment to improve the efficiency of EMC measurement facilities with rapid turnaround time, high throughput, and accurate measurements.

Radiated emissions



Conducted emissions



Typical emissions measurement challenges

- Hard to capture intermittent transient emissions
- Difficult to track the EUT operation state when the emissions appear
- Wide variations in the final test results due to EUT behavior or measurement conditions
- Challenging to obtain repeatable results
- Irrelevant emissions may be measured extending measurement time

How Keysight EMI receivers can help

- Enable real time scan (RTSC) function for gapless measurement capture over a wide FFT bandwidth
- Accurately determine the peak, quasi-peak and average levels simultaneously
- Capture all emissions from EUT without missing any broadband or narrowband disturbance signals
- Easy-to-use, rapid measurements facilitate advanced troubleshooting right in the test lab

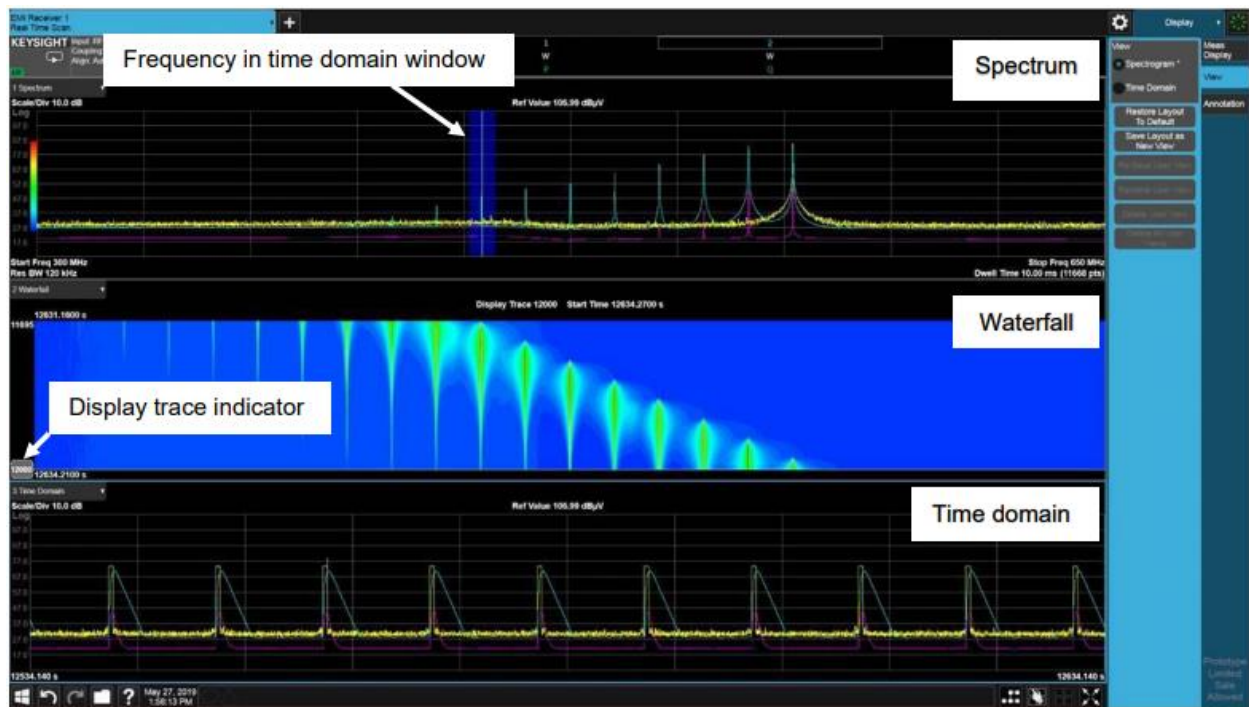


Figure 1. Real time scan measurement enable gapless measurement capture of up to 350 MHz FFT bandwidth

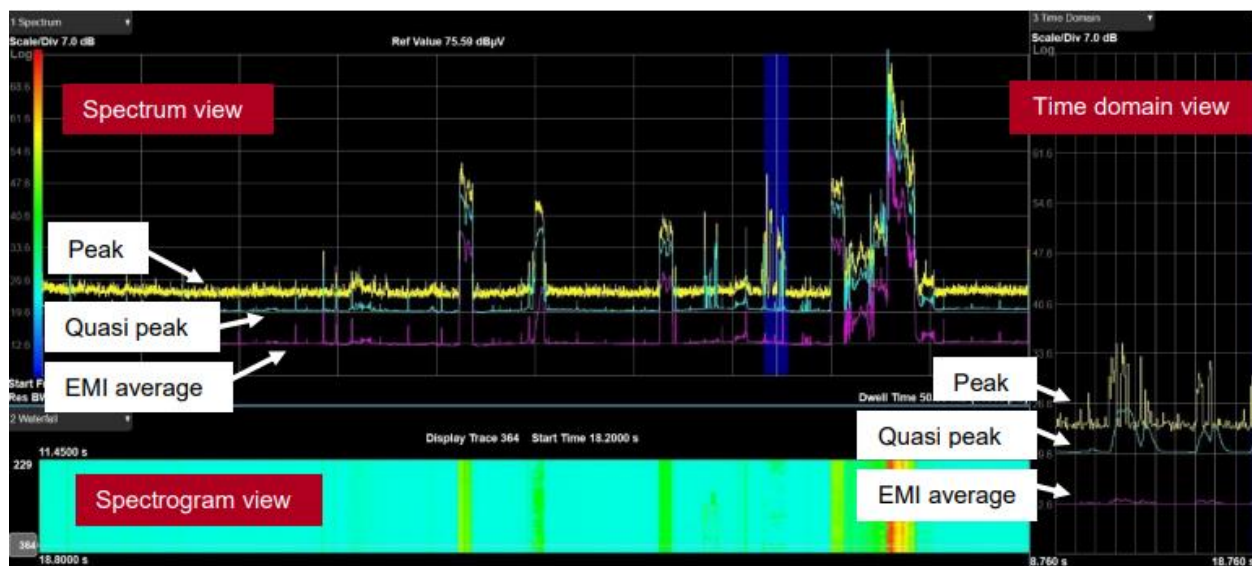
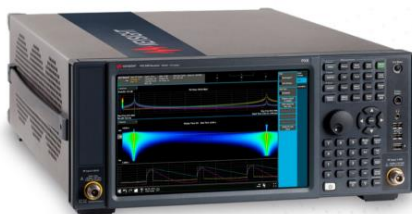


Figure 2. Multi-domain view enables users to analyze true noise behavior with gapless measurements

Explore Keysight EMI Receivers for Compliance Testing



For compliance testing

Keysight **N9048B PXE** is a standards-compliant EMI test receiver equipped with pre-selector and LNA designs. N9048B is a high-performance receiver and diagnostic signal analyzer built on an upgradable platform.

- Frequency range of 1 Hz – 44 GHz
- Fully CISPR 16-1-1:2019, MIL-STD-461G, ANSI C63.2 and FCC compliant
- Industry leading sensitivity and dynamic range
- Enable real-time scan (RTSC) for gapless signal capture and analysis up to 350 MHz bandwidth
- Simultaneous viewing of frequency domain, time domain and spectrogram for complete EUT noise capture and analysis

[Datasheet - N9048B PXE EMI Receiver](#)



For compliance testing

Keysight **N9038B MXE** is a mid-performance standards-compliance EMI test receiver and diagnostic signal analyzer. The MXE provides similar functionalities as the PXE except for the real-time scan for gapless signal capture.

- Frequency range of 3 Hz – 44GHz
- Maximum analysis bandwidth of 160 MHz
- Fully CISPR 16-1-1:2019, MIL-STD-461G, ANSI C63.2, and FCC compliant
- Reduce overall test time with time domain scanning enabled by fast Fourier transform (FFT) scans

[Datasheet – N9038B MXE EMI Receiver](#)

Useful Resources

- [Application note – Making EMI compliance measurements](#)
 - [Application note - Accelerate electromagnetic interference testing using real-time scan measurement](#)
 - [Application note – Boost EMC test throughput with Accelerated Time Domain Scan](#)
 - [Application note – Making conducted and radiated emission measurements](#)
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Electromagnetic Susceptibility (EMS) compliance testing

Radiated Immunity (RI) and Conducted Immunity (CI) testing assures the ability of the equipment under test to withstand radiated and conducted interference. A typical radiated immunity test system incorporates a signal generator, amplifier, field strength meter, antenna (horn or log periodic), an E-field probe, and power meters. All the instrumentation and testing are managed by EMC control software. A signal generator is used as an RI source, which is then passed through an RF power amplifier and radiated towards the EUT. For a radiated immunity test the signal is routed through an RF antenna while for a conducted test it is applied via a CDN (coupling/decoupling network). The interference level is calibrated by an electric field sensor (radiated) or a spectrum analyzer (conducted). An RF power meter is used to monitor the output from the RF power amplifier.

How Keysight solutions can help

Keysight together with partners offers a comprehensive range of solutions for RI and CI testing. The RI test solutions use Keysight EXG signal generator, EPM N1914A power meter and E9304A E-series power sensor and N9010B EXA signal analyzer. The CI test solutions include line interference generator and Electrostatic Discharge (ESD) Simulator from Keysight partners. Automated EMC software from Keysight partners controls of the instruments to ensure a fully automated test solution.

Explore Keysight products for immunity testing



N5171B EXG X-Series RF Analog Signal Generator, 9 kHz to 6 GHz

- Offer 9 kHz to 6 GHz frequency coverage
- Optimized for fast throughput and uptime at the right price
- Built-in AM and Pulse Modulation

[Datasheet – N5171B EXG](#)



N5181B/N5183B MXG RF and microwave analog signal generator

- MXG X-Series microwave analog signal generator offers 9 kHz to 40 GHz frequency coverage and near PSG levels of phase noise performance with advantages in size and speed.

[Datasheet – N5183B MXG](#)



N5182B RF Vector Signal Generator

- N5182B MXG X-Series RF vector high performance signal generators are fine-tuned to be your “golden transmitter” in R&D with 9 kHz to 6 GHz frequency coverage. Simulate real-world signals with real-time capabilities with Signal Studio software.

[Datasheet – N5181B Analog and N5182B Vector MXG](#)



N1914A Dual Channel Power Meter

- Frequency range of 9 kHz to 110 GHz (sensor dependent)
- Wide dynamic range of -70 to +44 dBm (sensor dependent)
- Go beyond GPIB with LAN LXI-C and USB connectivity
- Code-compatible with E4418/19B power meters and 436/7/8A power meters

[Datasheet – N1913A and N1914A EPM Power Meters and E-Series/8480-Series Power Sensors](#)



E9304A E-Series power sensor to 6GHz

- Low frequency coverage (9 kHz to 6 GHz) for EMC/EMI test applications
- High sensitivity (-60 to +20 dBm)
- Fast measurement speed to reduce the time taken to calibrate radiated field uniformity and EMI receivers



InfiniiVision 6000 X-Series oscilloscope

- 500 MHz, 1 GHz, 2 GHz, 2.5 GHz, 4 GHz, 6 GHz, 8 GHz
- 10 GSa/s, 100Mpts standard, up to 800 Mpts optional
- 4 channels + 16 digital channels
- 10 bits of vertical resolution
- Industry's largest 15-inch touch display

[Datasheet – 6000 X-Series Oscilloscope](#)

EMC Simulation using PathWave EDA Tools

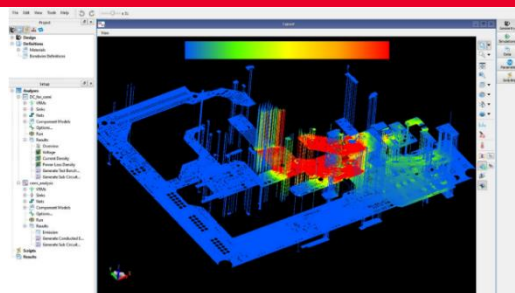
Design and test challenges

Most EMC testing time is spent on design optimization and failure troubleshooting. Waiting until hardware is built to find EMC failures can result in late in the design retrofits and product launch delays. Evaluating a device's EMC functionality using simulation software early in the product design phase can help mitigate potential EMC problems so that products can reach the market on time and at a lower cost.

How Keysight solution can help

Keysight offers a variety of simulation tools for addressing EMC challenges. The tools range from traditional 3D FEM and FDTD simulators in PathWave ADS EMPro to application focused tools like PathWave ADS with PiPro. The PathWave ADS PiPro tool enables fast post-layout PCB EM simulation with easy-to-use automated setups for Conducted EMI Analyses of PCB power rails. It enables the setup of differential excitation of the digital twin EUT, with system ground plane referencing to match conducted EMI test bench measurements. Spectrum limits for automotive conducted EMI compliance are included.

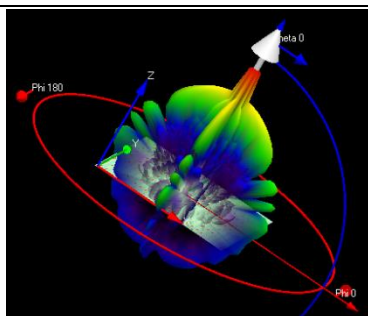
Explore Keysight EMC Simulation Software



The **W3036E** Conducted EMI (CEMI) PiPro add-on for the W3623B Power Integrity Bundle:

- Handles high density, high layer count PCB designs with cascaded regulator power delivery.
- Automates differential excitation with large signal switching converter noise sources.
- Fast simulation times with Harmonic-Balance

[Keysight - W3036E Conducted EMI with PiPro](#)



The **W4302B** PathWave EM Design Core, FDTD, Compliance Module:

- 3DEM solid modeling environment
- Finite Difference Time Domain (FDTD) simulator for electrically large structures
- Includes Specific Absorption Rate (SAR) and Hearing Aid Compatibility (HAC) compliance

[W4302B PathWave EM Design Compliance Module](#)

[Useful Resources](#)

[Webinar - Conducted EMI simulation made easy with PathWave ADS](#)

EMC Pre-Compliance and Troubleshooting Tools

Use case and challenges

Before any product is released to market, all electronic devices must pass an EMI compliance test. However, acquiring certification for EMI compliance testing is expensive – and if you don't pass – you not only have to rework your design but test failures could throw off your product development schedule and cost a lot of money. Being able to conduct EMI tests on your own can help ensure that your device passes as soon as it is sent to a test facility for certification. Pre-Compliance testing can be thought of as a dress rehearsal for compliance testing. Everything you do during pre-compliance testing ensures that your device passes when it is sent in for compliance testing, the final stage of EMC testing, at a certified test facility. You can test your device against the same standards that these test facilities will, but in the convenience of your own test lab.

Close field electromagnetic interference (EMI) tests are a valuable tool in electromagnetic compatibility (EMC) radiated emission pre-compliance testing. Close field testing is performed at 1 meter or less from the antenna. Far Field testing is performed at distances between 3 to 10 meters at test facilities using EMI receivers and antennas. The nature of the electromagnetic field is determined by the device under test (DUT) and the distance of the receivers and antennas from the DUT. A far field radiated emission measurement accurately determines if the DUT is compliant to related EMC/EMI standards.

However, far field testing has limitations. It is more difficult to identify the source of emissions. Radiated emissions may come from a USB port, a LAN port, the seam of a shield, a cable, or even a power cord. Close field testing is the best way to locate the exact source of the emission and is typically performed using a signal analyzer and close field probe. Close field testing is a relative test, meaning a comparison of the radiator's results to the rest of the device's results can help you address where redesign work is required. It should be noted that comparing close field test results with EMI standard test limits is difficult because a number of factors can affect the test readout, like the probe position and DUT shape.





- Identify out of limit device emissions
 - See device emissions typically hidden in the noise floor
 - Differentiate between ambient signals and EUT emissions
 - View signals over time to identify intermittent responses
- Maximize signals and compare against regulatory requirements
 - Built in commercial and mil-STD compliant bandwidths, detectors and band presets
 - Continuously monitor signals with bar meters to detect maximum amplitude
 - Compare measured emissions to regulatory limits.



- 10 Hz to 3.6 / 7 / 13.6 / 26.5 / 32 / 44 GHz frequency range
- Analysis bandwidth: 10 MHz (standard); 25 / 40 MHz (optional)
- Fast, flexible general-purpose signal analysis
- With **N6141EM0E** provides Amplitude probability distribution (APD), Time domain scan and Monitor spectrum
- Save test time in spurious response measurements with the fast sweep capability
- Get the most cost-effective analysis for millimeter-wave measurements



- 10 Hz to 3.6 / 8.4 / 13.6 / 26.5 / 32 / 44 / 50 GHz frequency range
- Analysis bandwidth: 25 MHz (standard); 40 / 85 / 125 / 160 MHz (optional)
- Quickly adapt to evolving test requirements of wireless devices
- Characterize signals from virtually any wireless devices



- With built-in CISPR compliant detectors RBW's and band presets
- Evaluate pre-compliance limits before formal compliance tests
- Identify issues like noise floor rise and interference generated by other equipment

Explore Keysight products and accessories for pre-compliance testing and troubleshooting



Keysight **N9311X RF and Microwave Accessory Kit** complements Keysight **FieldFox** and EMI receivers. These accessories provide you with a complete solution when troubleshooting your most challenging EMI failures.

- Covers frequency range from 30 MHz to 3 GHz
- Consists of four-probe set provides an effective combination of sensitivity, resolution, and diversity.
- For use with EMI pre-compliance measurement software and signal analyzer

[Technical Overview – N9311X RF and microwave accessory kit for low-cost handheld and benchtop solutions](#)

Useful Resources

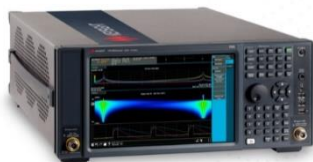
- [Webpage - Fundamentals of EMC Pre-Compliance](#)
 - [White paper – EMI troubleshooting: The need for close field probe](#)
 - [Youtube video – N9311X-100 Near Field Probes | N9000A CXA signal analyzer](#)
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Complete EMI and EMS Test Systems with Partners

Keysight and EMC partners offer complete EMI/EMS test systems to meet your exact requirements in EMS and EMI testing. Keysight test instrumentation with accessories and software from EMC partners enable automated, semi-automated and manual measurements for radiated and conducted emission and immunity testing. Measurements can be made on an open area test site (OATS), in an anechoic chamber, a shielded room, or a GTEM cell.

Explore Keysight complete EMI And EMS test system with solution partners

Keysight products for EMC testing



PXE/MXE EMI receiver

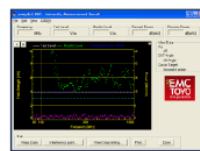


EXG/MXG Signal Generator



N1914A EPM Power Meter and
E9304A Power Sensor

Complete EMI/EMS System from Solution Partners



EMC software



Chamber

Antenna and
mast



GTEM CELL



310N preamplifier



N9010B EXA signal analyzer
(recommended)

Integrated system

Useful Resources

- [Keysight and ETS-Lindgren Solutions for EMC Test](#)
- [Keysight and Toyo Corporation EMC Measurements](#)



Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.

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